Vertical profiles of droplet size distributions derived from cloud-side observations by the Research Scanning Polarimeter: tests on simulated data

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The Research Scanning Polarimeter (RSP) is an airborne along-track scanner measuring the polarized and total reflectances in nine spectral channels. Its unique angular resolution coupled with the high frequency of measurements allows for accurate characterization of liquid water cloud droplet sizes using the rainbow (cloud bow) structure, which is observed in the polarized reflectance over the scattering angle range from 135° to 165°. RSP's observations also provide geometric constraints on the cumulus cloud's 2D cross section between a number of tangent lines of view, yielding estimates of the cloud's geometric shape, dimensions, and height above the ground.

In this study for the first time we evaluate the possibility to retrieve vertical profiles of microphysical characteristics along the illuminated side of the cumulus cloud using a combination of previously developed micro- and macrophysical retrieval methods. First, we determine the cloud shape; then for each point on the bright side of cloud surface we aggregate view-lines passing through it in order to construct the polarized reflectance as a function of scattering angle corresponding to that point. After this the rainbow structure of this reflectance is analyzed yielding the droplet size distribution (DSD) at that point. These are then combined into vertical profiles of the droplet size distributions and their parameters.

We present the results of testing the proposed profiling algorithm on simulated data. For these tests we modeled RSP measurements of a cloud using large eddy simulations and 3D radiative transfer computations. These "measurements"" were analyzed, and the retrieved profiles were compared to the actual data from the LES-model output. A cumulus congestus (towering cumulus, Tcu) cloud was selected for testing of the profiling algorithm in preparation for analysis of real measurements during the upcoming Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP^{2}Ex). We demonstrate that the use of the non-parametric Rainbow Fourier Transform (RFT) allows for adequate retrieval of the complex altitude-dependent bimodal structure of Tcu's DSDs, thus, paving the way for RSP-based process-oriented cloud remote sensing.

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